Background on Adaptive Management and Decision Support Systems

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Decision support tools

Ideally an easy-to-use quantitative tool for evaluating tradeoffs

A tool that can:

- Incorporate monitoring data
- Involve scientists working within TRRP
- Allow decision makers to evaluate tradeoffs
- Identify key uncertainties that make decisions difficult

Decision support tools

Integrated decision support tools are most effective when:

1) Decisions are revisited regularly
2) Decisions can be informed by ongoing monitoring
3) **Managers and scientists take ownership of the process**

Decision analysis-- structured decision making-- adaptive resource management--- decision support tools– decision support systems

Some background

Decision theoretic approaches

- Developed turn of 20th century
- Initially business applications
- 1970's natural resource decision making

Adaptive resource management

- Special case of DA
- Feedback from monitoring

Decision Support Process

Requires thought (time to think)

Break down problem into manageable parts

Management objectives

- what do you really want to accomplish?

Alternative decisions/ actions

Link decisions with objectives

- a model

Evaluate sensitivity of decisions to assumptions

identify monitoring endpoints

estimate required effort- evaluate tradeoffs

Link with monitoring (ARM)

Don’t we already do this?

Confusion over objectives (fundamental vs. means)

Confusion between goals/ objectives and beliefs/ technical uncertainty

Failure to adequately consider sources of uncertainty (blind faith in models)

Failure to incorporate research and monitoring into decision making (to reduce uncertainty)➔ inefficient use of resources

Why model decisions?

Quantitative methods should guide and support decision making

Not a replacement for human intuition and subjectivity

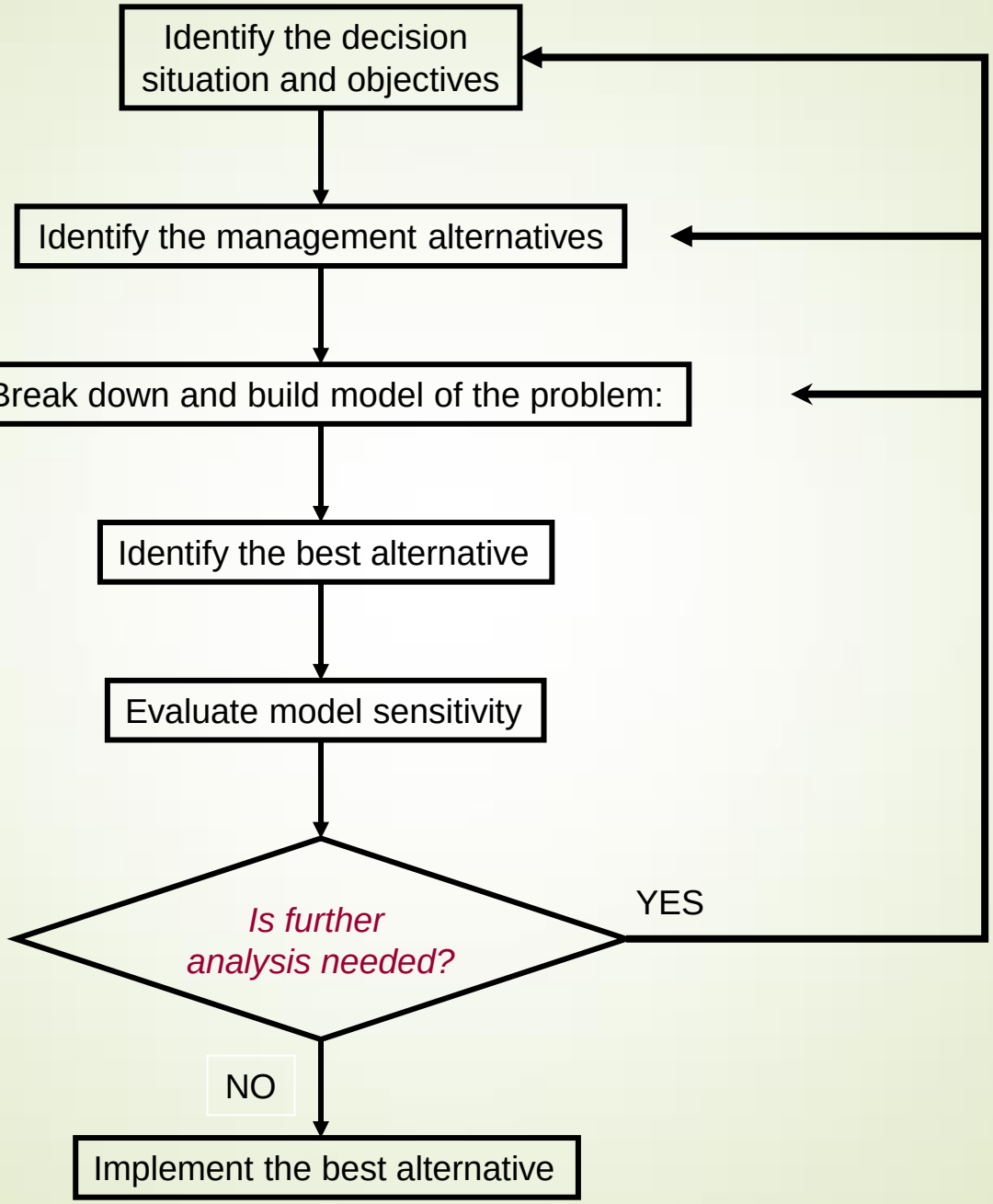
At least- be an intelligent consumer of models for decision making

Better: collaborate on model development

Models for conservation are *not* about modeling--
- they are about conservation

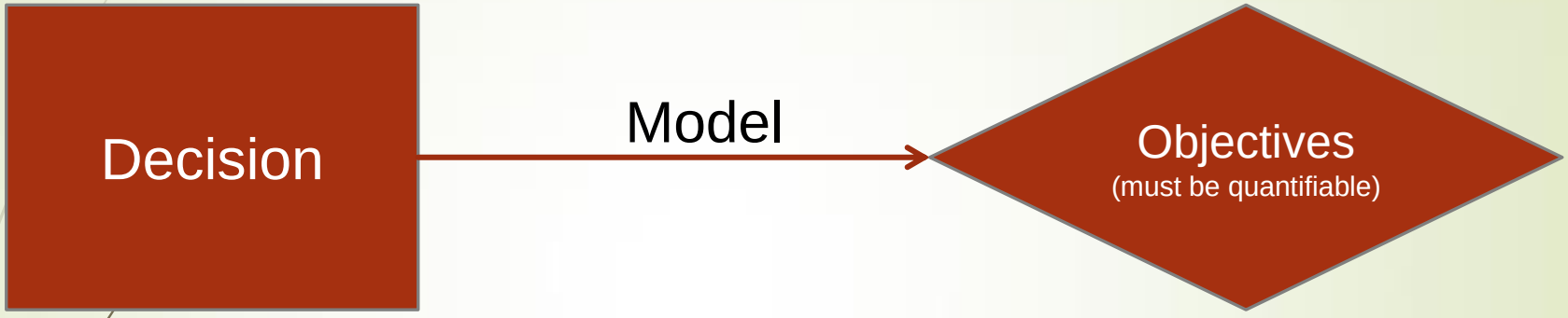
The Big Picture

Decision support process



Step 2: Identify and Structure Objectives

Why emphasize objectives?



Everything depends on your objectives

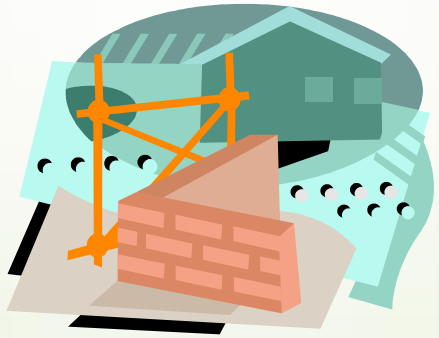
Everything depends on your objectives

Everything depends on your objectives

Basic types of objectives

Fundamental objectives: what the decision-maker really wants to accomplish.

Means objectives: the things that need to be accomplished to realize the fundamental objective



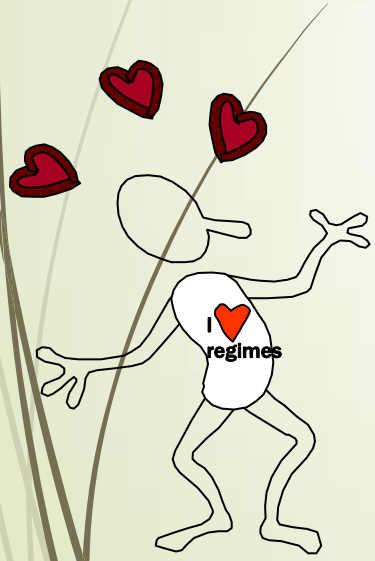
>>>>>> Clarity is essential <<<<<<

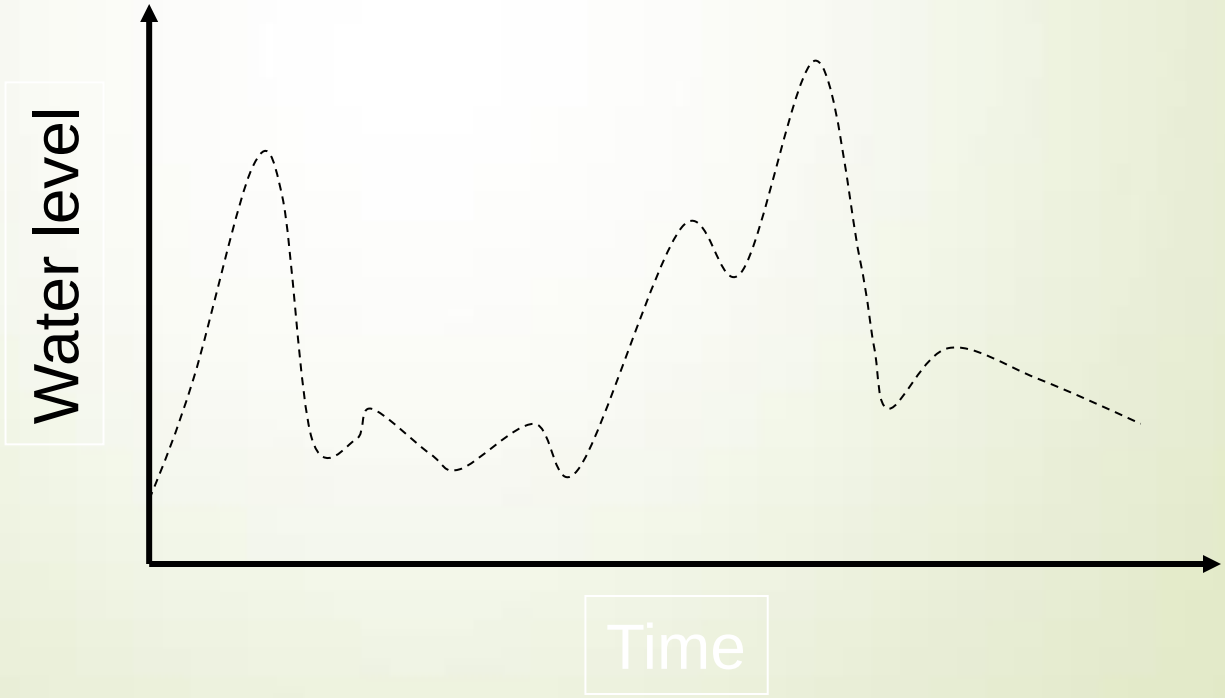
The importance of identifying and structuring objectives common sticking point

Confusing fundamental and mean objectives

Stated (fundamental) objective of stream fishery manager:

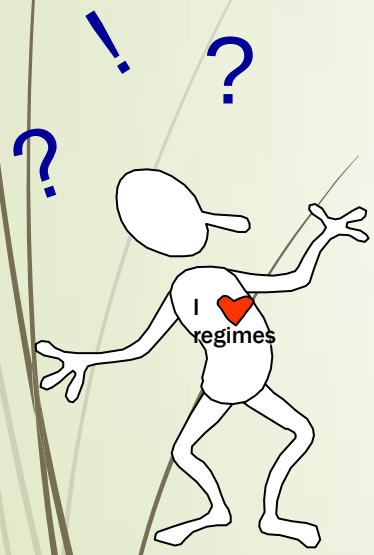
Natural Hydrologic Regime

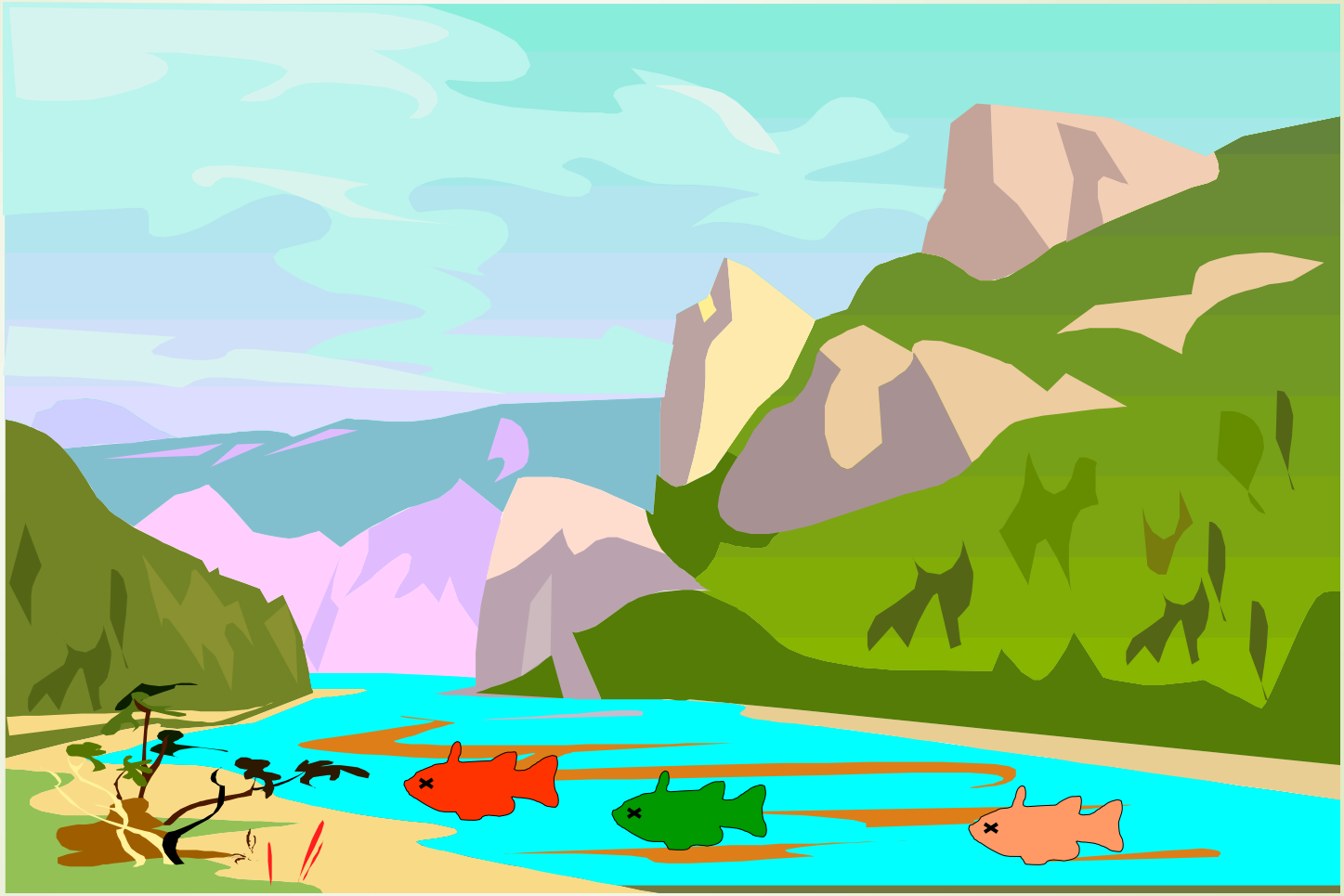




Possible outcome: The flow regime is natural but….

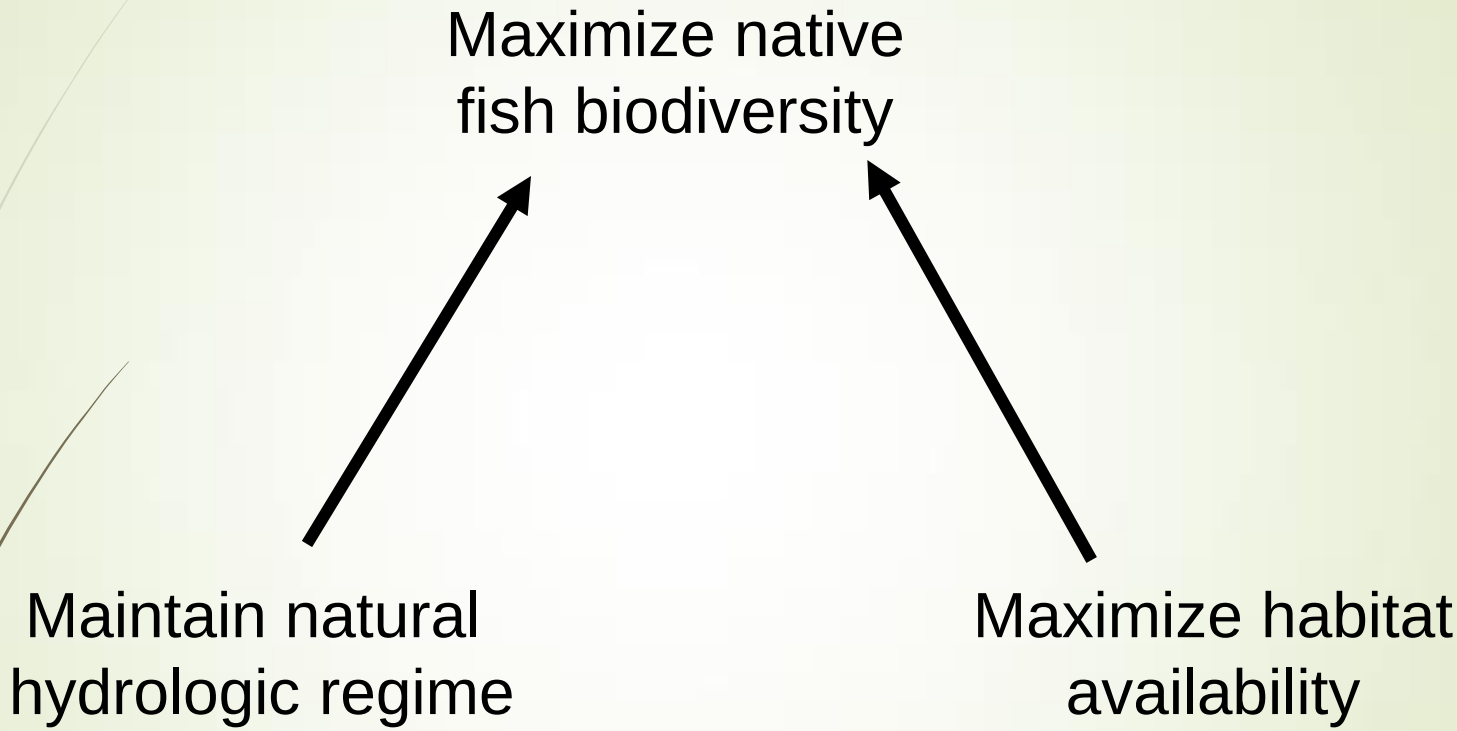
all the fish are dead





Would the fishery manager be happy with the outcome???

Means objectives (sometimes) help realize the fundamental objective



Means objectives often are hypotheses about system dynamics

More common problems

Dismissing potential objectives due to perceived conflicts

Dismissing potential objectives due to perceived lack of information or complexity

Values (objectives) masquerading as facts or process

Decision Support Process

Step 1: Identify the problem / decision situation

Step 2: Identify and Structure Objectives

Step 3: Identify decision alternatives

These 3 steps = most difficult aspects of process

Step 4: Model building

Construct the model (decision support tool)

- Simple (simple is good!)
- Complex (can do but-- the rule of 6)
- *But…Must include uncertainty*

Where do we get the information?

- Empirical data
- Published reports (meta-analysis)
- “Expert” judgment

Common forms of uncertainty in natural resources management decision making

Linguistic

Epistemic
- Statistical uncertainty
- Observational error
- Structural uncertainty

} Reducible

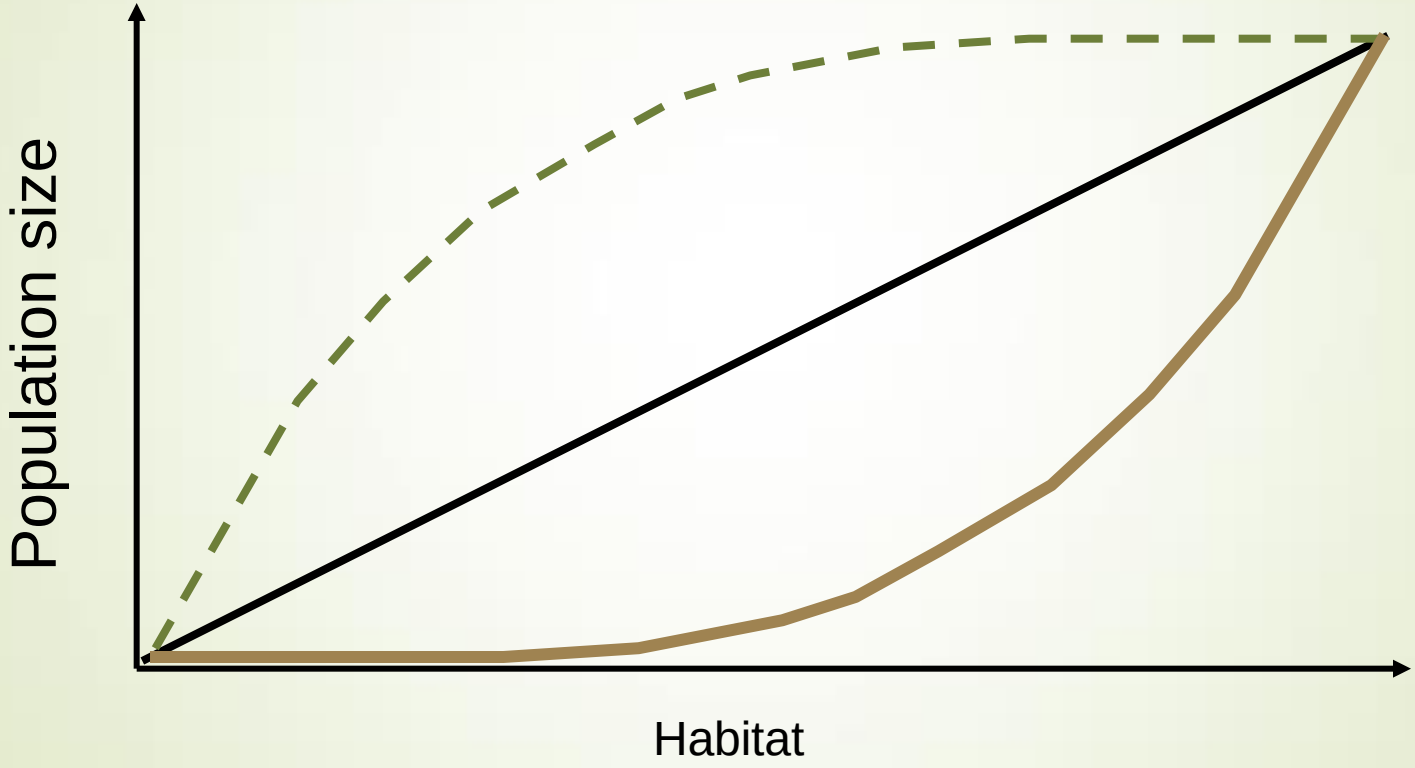
Aleatory
- Environmental variability
- Demographic variability

} Irreducible

Often overlooked source of uncertainty

Structural (System) uncertainty

due to incomplete understanding of system dynamics



Incorporated into decision modeling using multiple models and model probabilities (weights)

Step 5: Identify key uncertainties—*Sensitivity Analysis*

An essential step

Basis for model simplification

Focus monitoring on decision-making

- **what do we need to know**
- **how much is enough**

Estimate value of information

- **collecting monitoring data**
- **more studies**

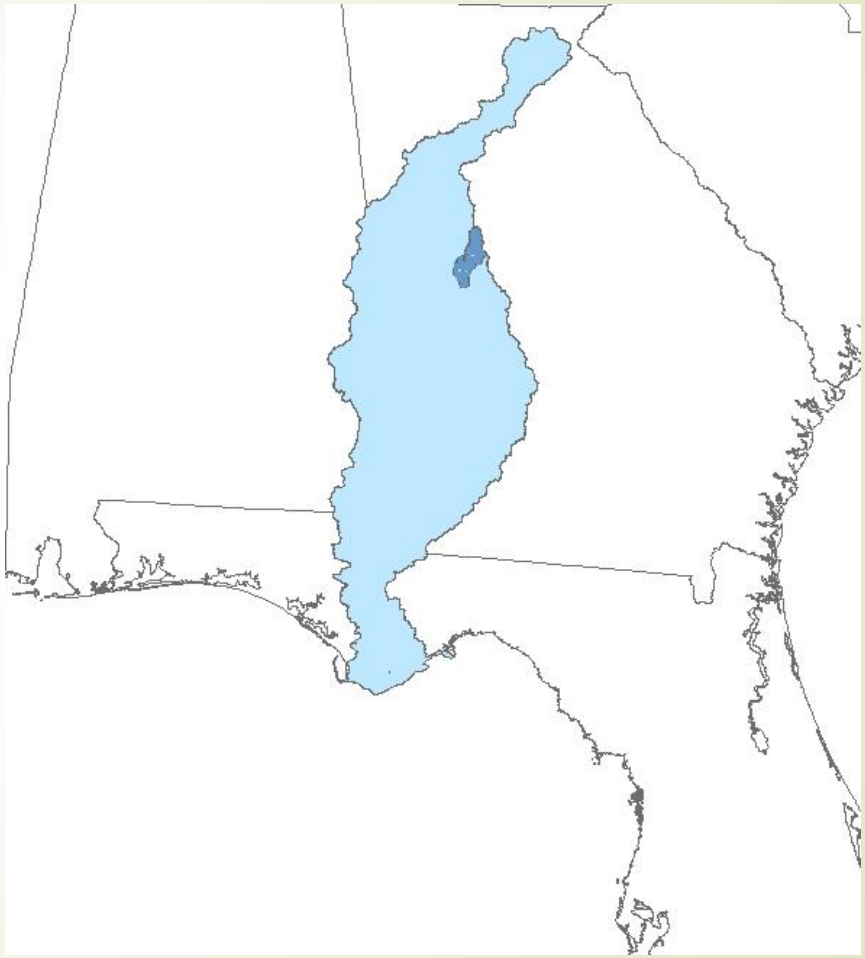
Example: Water availability for ecological needs in the ACF Basin

Spatially explicit
- Stream segment
- Flow, habitat, fish metapopulation models (43 species)

Statistical uncertainty
- Flow and habitat model errors

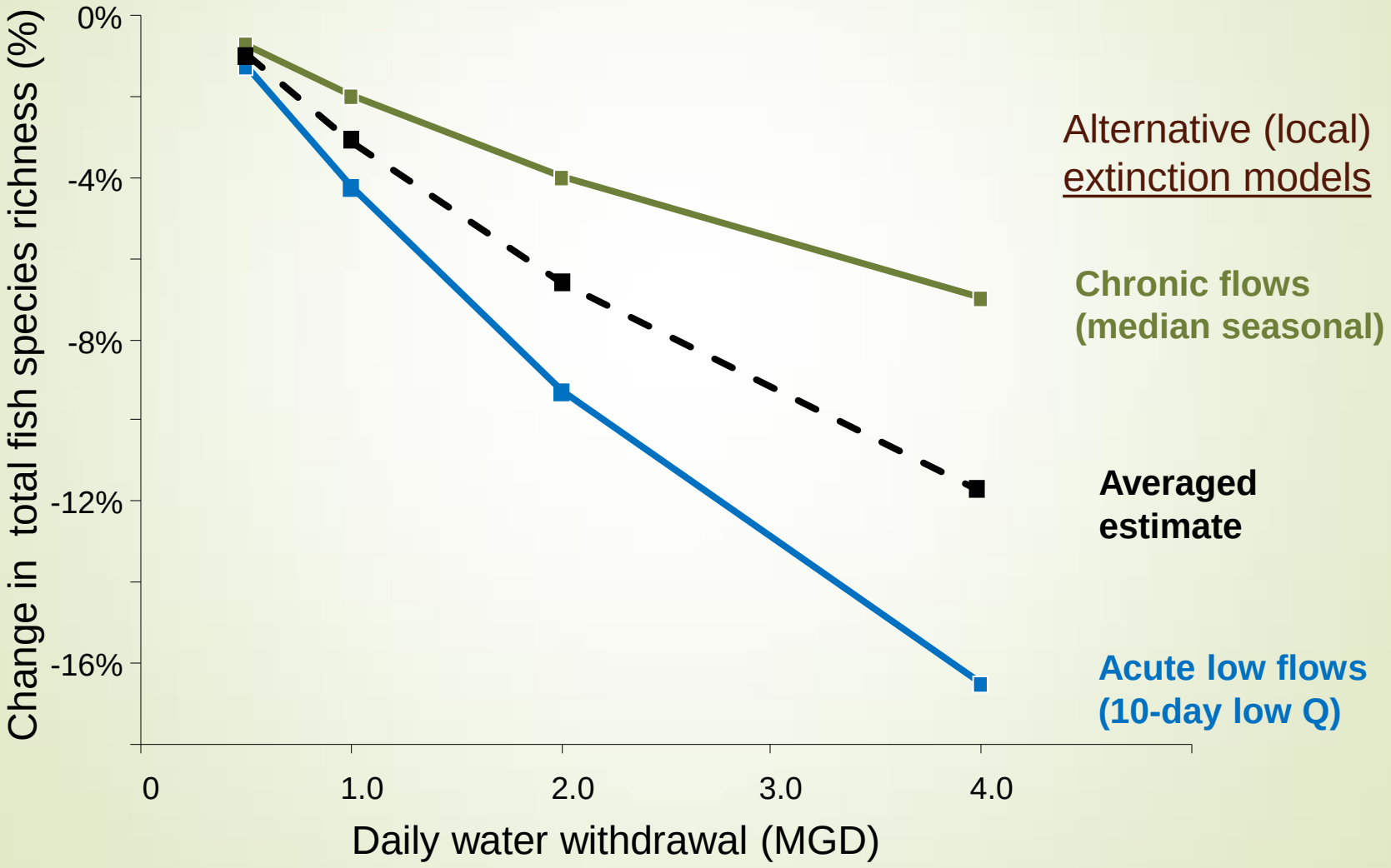
Structural (system) uncertainty
- Alternative fish population demographics models

Apalachicola, Chattahoochee, Flint Basin



Peterson and Freeman 2016

What assumptions/inputs affect the decision?



Value of information

Expected value of decision if no uncertainty

- Model parameters
- Model inputs and system state

Currency that is valued by the decision-makers

- Fish population size
- Water available for use
- Others

Value of imperfect information

Value of sample information

Multi-species occupancy simulations

2 sample occasions, error (CV) ~ 35%

True richness, given estimated 25: 25 +/- 4

Value of sample information: 0.26 MGD

4 sample occasions, error (CV) ~ 10%

True richness, given estimated 25: 25+/- 2

Value of sample information: 0.49 MGD

Compare to EVPI = 0.61

Reducing Uncertainty

Retrospective studies

- Can provide a good initial basis for prediction
- Usually confounded with other factors

Experiments

- Difficult to perform in many systems
- Uncertainty reduction is *not* directed at resource objective (inefficient)

Adaptive management

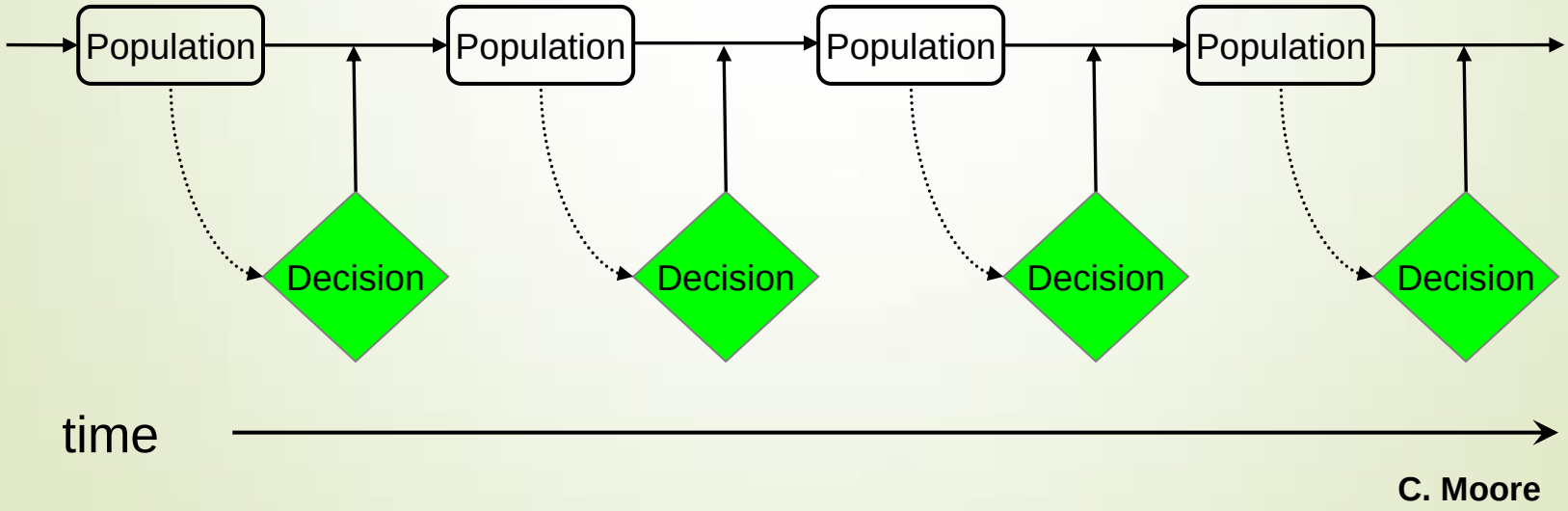
- Can be done in virtually any resource system
- No tradeoff necessary in resource objective

Learning how a system works

Learn while managing (Adaptive Resource Management)

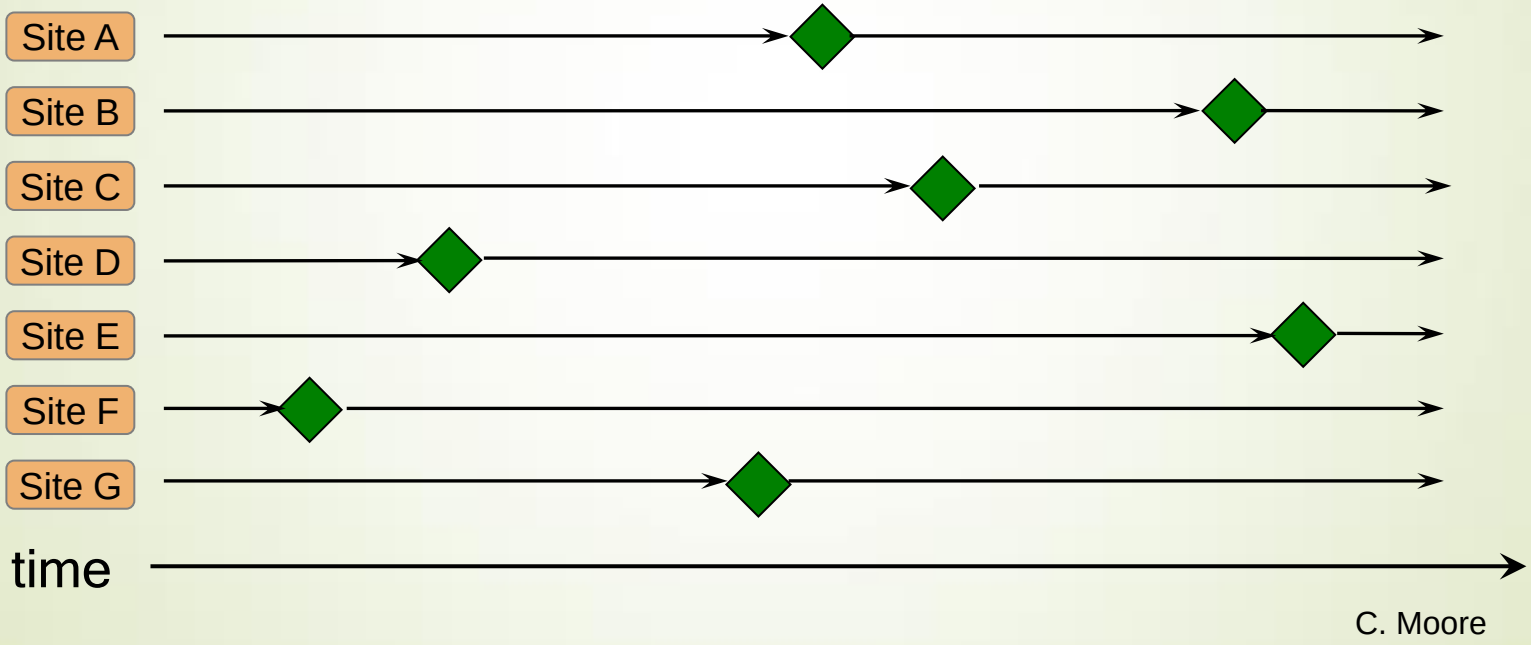
- Decisions are made
- Requires *sequential dynamic* decision-making: time and/or space
- Probing (aka experimentation) not *necessary*

Sequential decision-making through time



Learning how a system works

Sequential decision-making through space



C. Moore

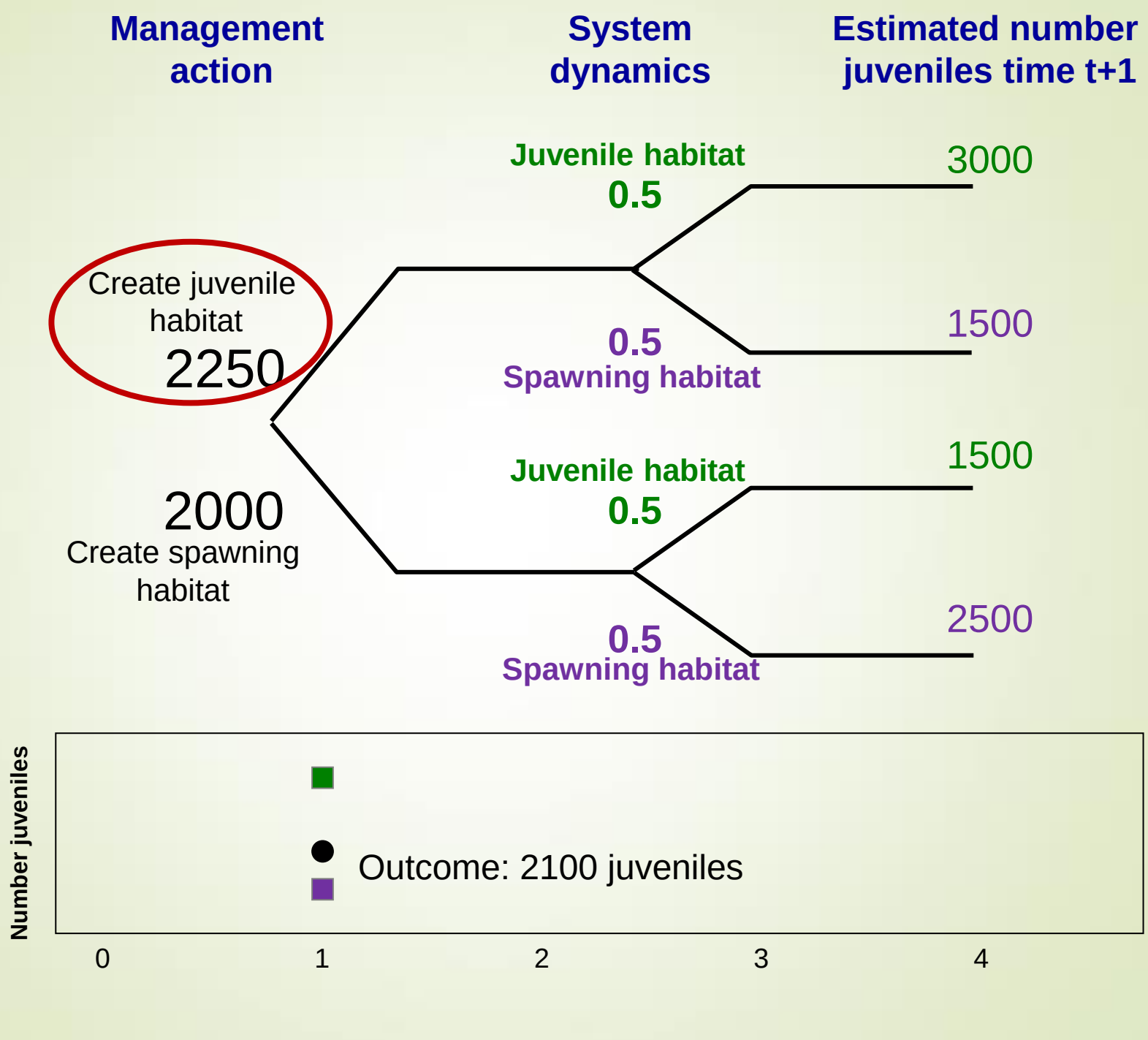
An illustration: Dueling professors

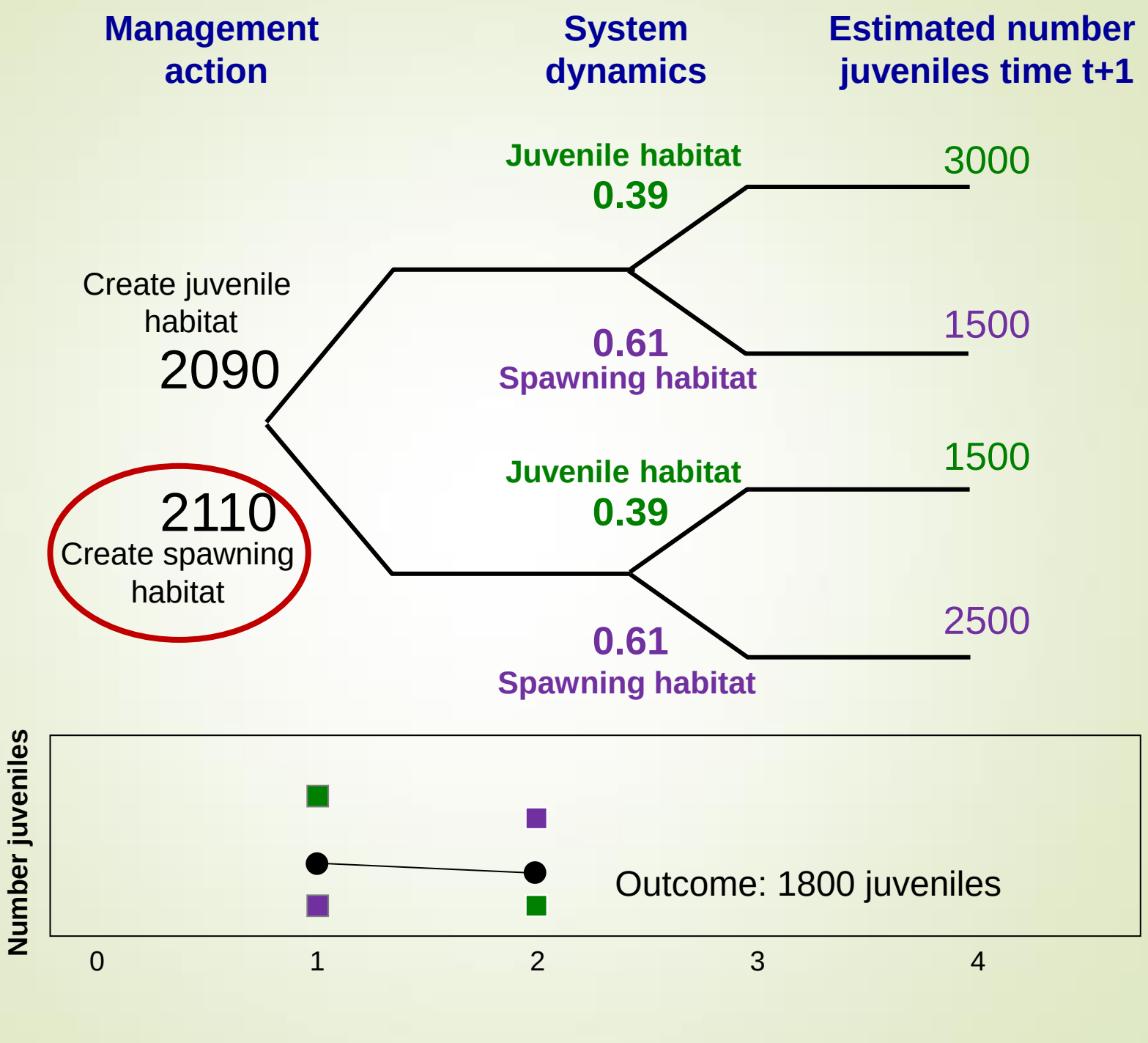
We have two potential management actions for swamp suckers: **increasing spawning habitat** or **increase juvenile rearing habitat** *(we don't have enough money to do both!)*

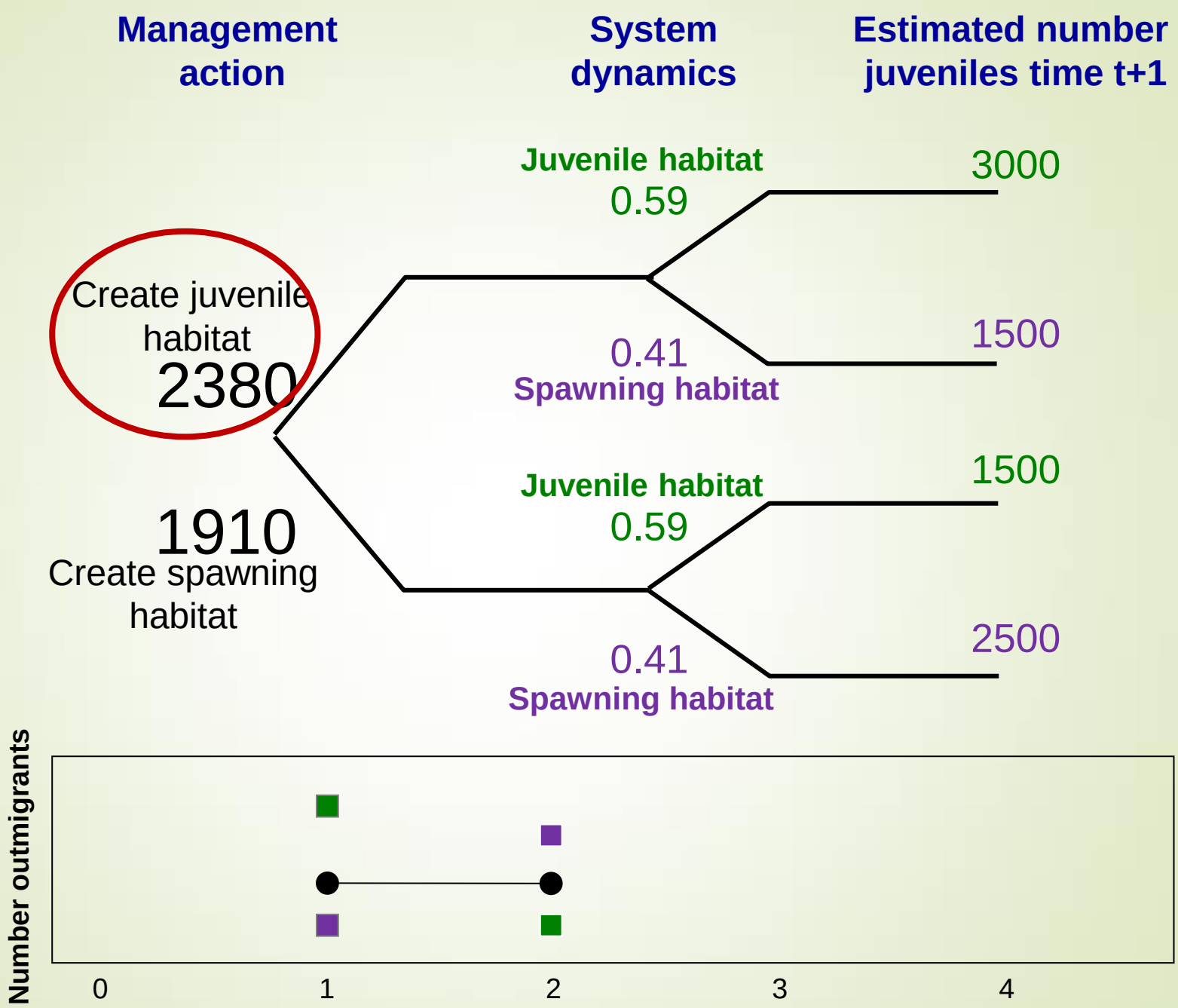
Professor Knowsitall, says that spawning habitat is limited. She estimates that there will be 2500 juvenile suckers produced if spawning habitat is increased, 1500 if not

Professor Nottoobrite thinks that juvenile rearing habitat is limited. He estimates that there will be 3000 juvenile suckers produced if rearing habitat is increased, 1500 if not

What do we do?….


Management action
System dynamics
Estimated number juveniles time t+1
Create juvenile habitat
2250
2000
Create spawning habitat
Juvenile habitat
0.5
Spawning habitat
0.5
Juvenile habitat
0.5
Spawning habitat
0.5
3000
1500
1500
2500
Number juveniles
Outcome: 2100 juveniles
0
1
2
3
4


Management action
System dynamics
Estimated number juveniles time t+1
Juvenile habitat
0.39
3000
Create juvenile habitat
2090
0.61
Spawning habitat
1500
1500
Juvenile habitat
0.39
2110
Create spawning habitat
2500
0.61
Spawning habitat
Number juveniles
Outcome: 1800 juveniles
0
1
2
3
4


Management action
System dynamics
Estimated number juveniles time t+1
Create juvenile habitat
2380
1910
Create spawning habitat
Juvenile habitat
0.59
3000
0.41
Spawning habitat
1500
Juvenile habitat
0.59
1500
0.41
Spawning habitat
2500
Number outmigrants
0
1
2
3
4

Example: Reducing uncertainty
ACF Basin: monitoring

Spring and summer 2011- 2013

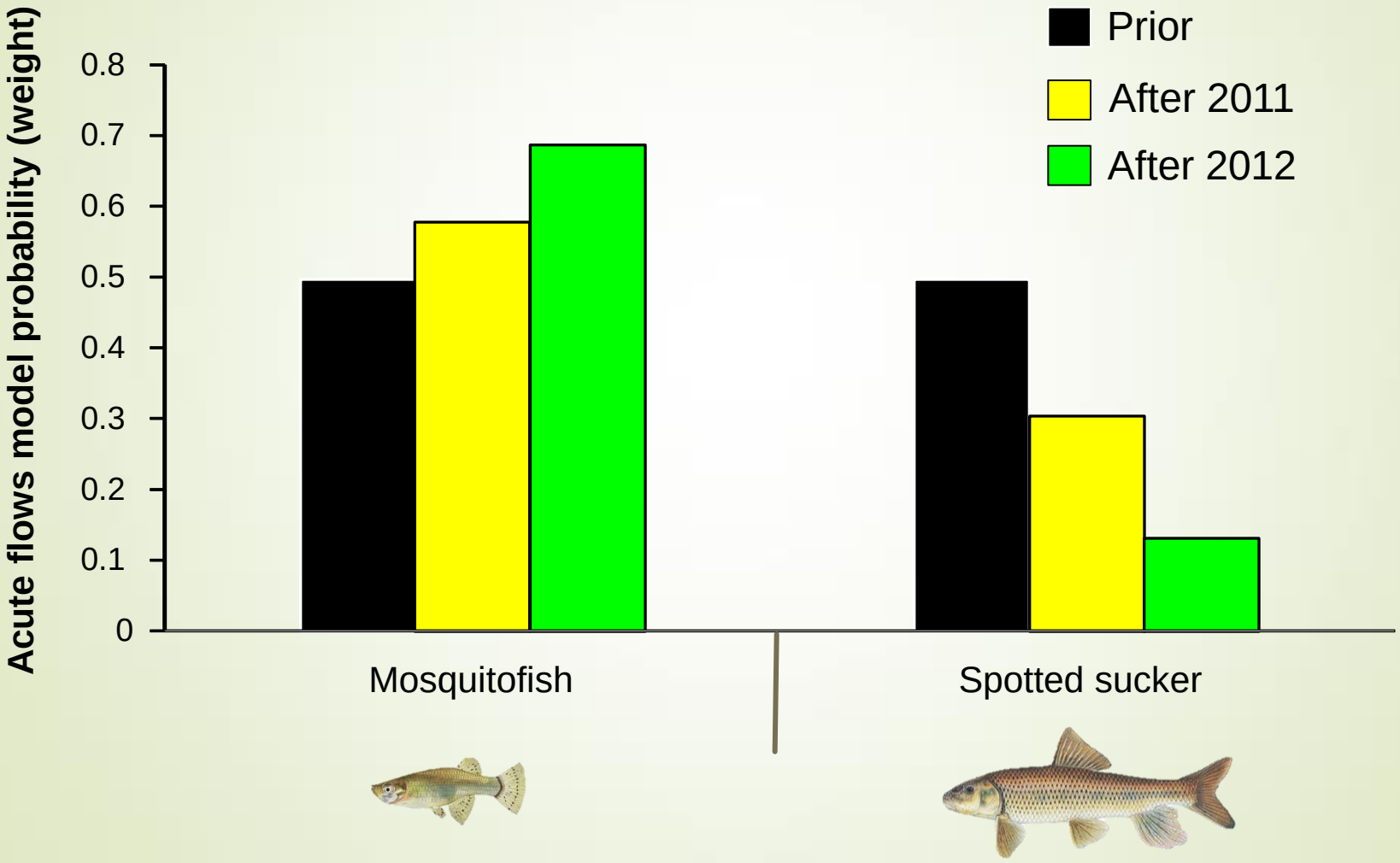
21 sites, 40- 100 m

Electrofishing and seining

Occupancy 2-3 visits season

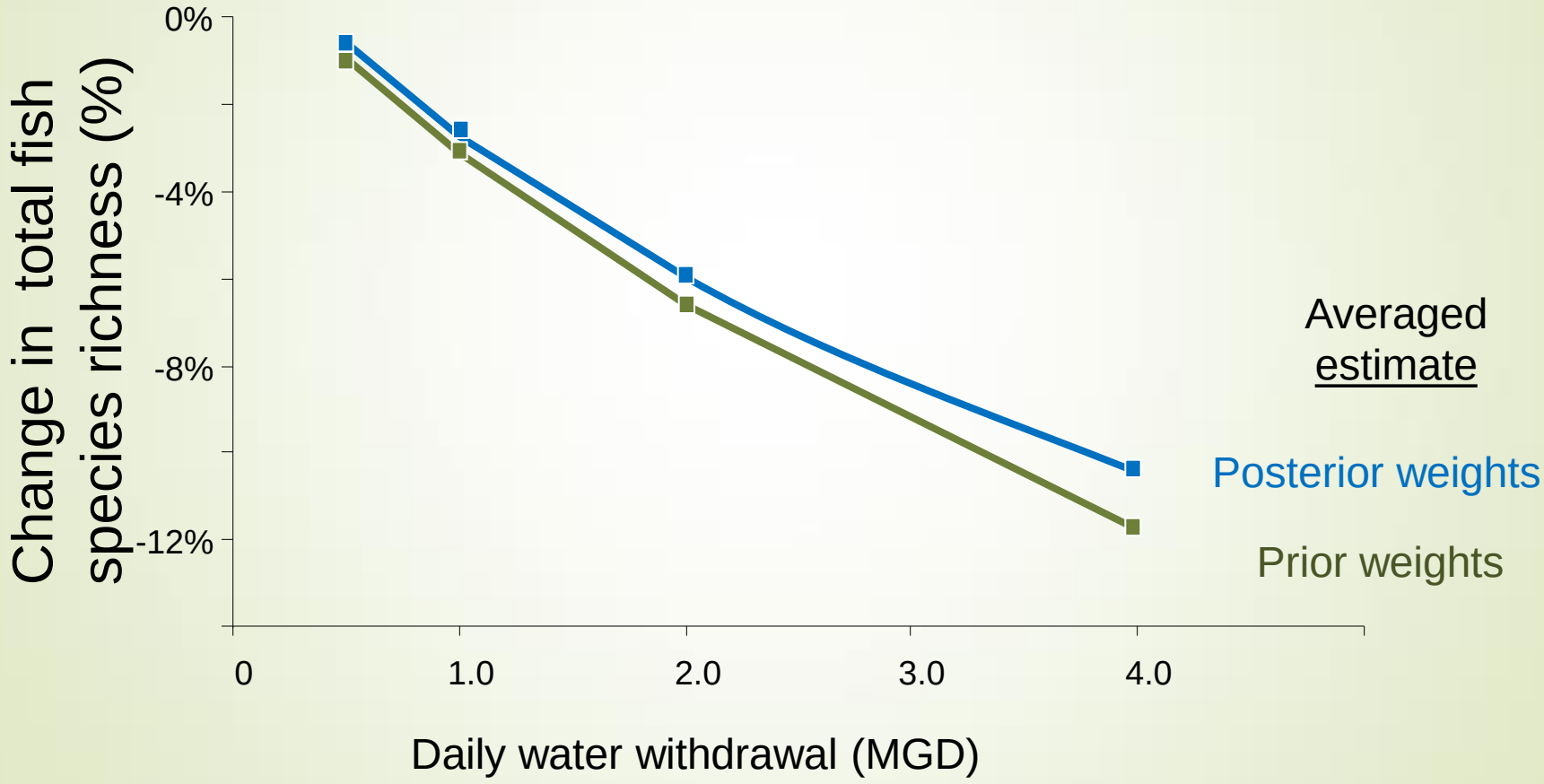
Flint River Basin

Update model probabilities



Peterson and Freeman 2016

Updated estimates of water use effects



Role of monitoring

Traditional approach

Current state of the system

Trajectory (trends)

Integration of information *indirect*

Potential loss of information (knowledge)

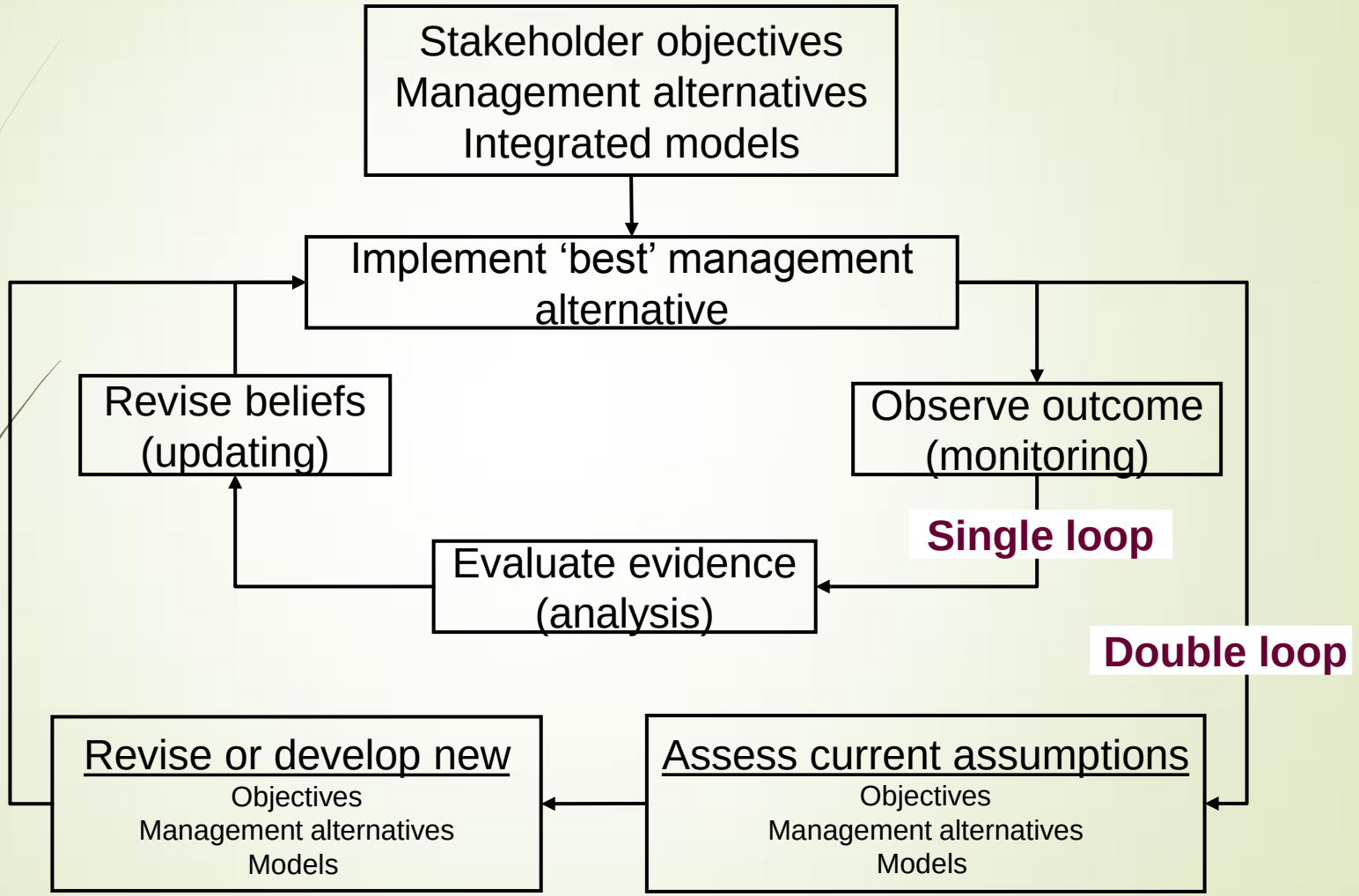
Adaptive resource management (ARM)

Current state of the system

Information on system dynamics

Integration of information *direct*

Institutional memory contained in model(s)

What if the models are wrong?

Single and double loop learning